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Understanding the generation and evolution of reaction-induced porosity in the replacement of calcite by gypsum: A combined microscopy, X-ray micro-tomography, and USANS/SANS study

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Fluid-mediated mineral replacement reactions are common in natural systems and are essential for geological and engineering processes. In these reactions, a primary mineral is replaced by a product mineral via a mechanism called coupled dissolution-reprecipitation. This mechanism leads to the preservation of the shape of the primary mineral into the product mineral. The product mineral includes reaction-induced porosity contributing to enhanced permeability, which is crucial for the replacement reaction to progress from the surface to the core of the primary mineral grain. These reaction-induced pores are complex in size, shape and connectivity, and can evolve with time. However, the mechanisms of the creation and evolution of such pores are still poorly understood. Therefore, we investigated the replacement of calcite (CaCO_3) by gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) to understand porosity creation in the replacement stage and the evolution of such porosity after complete replacement. This replacement reaction is important for the applications such as groundwater reservoir evaluation, CO_2 sequestration, cultural heritage preservation, and acid mine drainage remediation. Samples collected at various reaction stages over 18 months were characterised by ultra-small-angle neutron scattering and small-angle neutron scattering (USANS/SANS), ultra-high-resolution electron microscopy (UHR-SEM), and X-ray micro-computed tomography (X- μ CT). Results show the formation of micro-voids in the core of the gypsum grain and the generation of nanometre-sized elongated pores in the newly formed gypsum crystals. Micrometre-sized pores were mostly open, while pores smaller than 30 nm were mainly closed. After complete replacement, continued porosity coarsening occurred in the 18 months' time, driven by Ostwald ripening.

Level of Expertise

Student

Presenter Gender

Man

Pronouns

Which facility did you use for your research

Australian Centre for Neutron Scattering

Students Only - Are you interested in AINSE student funding

Yes

Do you wish to take part in the Student Poster Slam

No

Condition of submission

Yes

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